AFRL-IF-RS-TR-2000-89
Final Technical Report
June 2000

MODULAR AUTOMATED TEST EQUIPMENT (MATE) 390 ENHANCEMENT PROGRAM

BAE Systems

David R. Carey

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

AIR FORCE RESEARCH LABORATORY
INFORMATION DIRECTORATE
ROME RESEARCH SITE
ROME, NEW YORK

DTIC QUALITY INSPECTED 4

20000802 233

This report has been reviewed by the Air Force Research Laboratory, Information Directorate, Public Affairs Office (IFOIPA) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be releasable to the general public, including foreign nations.

AFRL-IF-RS-TR-2000-89 has been reviewed and is approved for publication.

APPROVED: James M Nagy

JAMES M. NAGY
Project Engineer

FOR THE DIRECTOR:

NORTHRUP FOWLER, Technical Advisor
Information Technology Division
Information Directorate

If your address has changed or if you wish to be removed from the Air Force Research Laboratory Rome Research Site mailing list, or if the addressee is no longer employed by your organization, please notify AFRL/IFTD, 525 Brooks Road, Rome, NY 13441-4505. This will assist us in maintaining a current mailing list.

Do not return copies of this report unless contractual obligations or notices on a specific document require that it be returned.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
JUNE 2000

3. REPORT TYPE AND DATES COVERED
Final Aug 97 - Apr 00

4. TITLE AND SUBTITLE
MODULAR AUTOMATED TEST EQUIPMENT (MATE) 390 ENHANCEMENT PROGRAM

5. FUNDING NUMBERS
C - F30602-95-D-0028/0016
PE - N/A
PR - 2982
TA - QE
WU - 17

6. AUTHOR(S)
David R. Carey

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
BAE Systems
111 East Chestnut Street
Rome NY 13440

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Air Force Research Laboratory/IFTD
525 Brooks Road
Rome NY 13441-4505

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
AFRL-IF-RS-TR-2000-89

11. SUPPLEMENTARY NOTES
Air Force Research Laboratory Project Engineer: James M. Nagy/IFTD/ (315) 330-3173

12a. DISTRIBUTION AVAILABILITY STATEMENT
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This effort evaluated the effects of enhancing automatic test equipment hardware and software on the test program sets currently on the Automatic Test Equipment. Objective was to determine the relationship between the hardware and software of the Automatic Test Equipment and the Test Program Sets operating on the System.

14. SUBJECT TERMS
Automatic Test Equipment (ATE), Test Program Sets (TPS), Hardware Modifications, Software Rehost

15. NUMBER OF PAGES
24

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

TABLE OF CONTENTS

List of Tables

1.0 INTRODUCTION

The objective of this effort was to enhance depot maintenance capability for A-10 units under test (UUT) by upgrading their test equipment, the MATE 390. In it's original incarnation the MATE 390 test system was controlled by a Micro VAX computer. PC technology, including memory and speed have improved so dramatically over recent years that the PC is now many times faster and more powerful than the Micro VAX Workstation controller. In this program, the MATE 390 test system was re-engineered to replace the Micro VAX with a PC controller.

The project was divided into phases. Phase 1 was the VAX to PC upgrade using SCO-UNIX as the operating system platform on the PC. The second phase was to install the Windows NT operating system and National Instruments LabVIEW test programming environment on the PC. Each phase has a plethora of subtasks that will be described in detail in this document.

2.0 BACKGROUND

When the MATE 390 was originally designed the Micro-VAX II was the latest mini computer on the market. It was more powerful than the personnel computers available at the time. This section will list the various programs and the times required compiling and executing them. The times illustrate the need to upgrade the MATE 390 from a VAX to a PC.

2.1 TEST PROGRAMS

The UUT test program sets and Interface Test Adapters (ITAs) that are currently hosted and operational on the MATE 390 are listed below. Throughout this document, the term UUT TPS refers to the list below, including ITAs.

Table 1. Operational UUT TPSs and ITAs

CPIN	CIRCUIT CARD ASSEMBLY	NSN	TECH ORDER
85E-USQ85/M390-U013-00A	091150-302	5998-01-191-7026	5E18-2-2,-3,-4
85E-USQ85/M390-U004-00A	091200-302	5998-01-191-7027	5E18-2-2,-3,-4
85E-USQ85/M390-U005-00A	091250-302	5998-01-191-7028	5E18-2-2,-3,-4
85E-USQ85/M390-U006-00A	091300-302	5998-01-390-7541	5E18-2-2,-3,-4
85E-USQ85/M390-U007-00A	091350-304	5998-01-191-7031	5E18-2-2,-3,-4
85E-USQ85/M390-U014-00A	091450-303/304	5998-01-191-7032	5E18-2-2,-3,-4
85E-USQ85/M390-U014-00A	091460	5998-01-323-0633	5E18-2-2,-3,-4
85E-USQ85/M390-U008-00A	091600-303	5998-01-323-0633	5E18-2-2,-3,-4
85E-USQ85/M390-U009-00A	091650-303	5998-01-191-7034	5E18-2-2,-3,-4
85E-USQ85/M390-U011-00A	091750-301	6130-01-191-6785	5E18-2-2,-3,-4
85E-USQ85/M390-U001-00A	090280-303	5998-01-201-6849	5E19-2-2,-3,-4
85E-USQ85/M390-U002-00A	090285-301	5998-01-201-6850	5E19-2-2,-3,-4
85E-USQ85/M390-U003-00A	090290-303	5998-01-201-6851	5E19-2-2,-3,-4
85E-USQ85/M390-U010-00A	092300-301	5998-01-193-8135	33D7-61-96-2,-3,-4
85E-USQ85/M390-U012-00A	092450-301	5998-01-290-9889	33D7-61-96-2,-3,-4
85E-USQ85/M390-U015-00A	092500-301	5998-01-191-9482	33D7-61-96-2,-3,-4
85E-USQ85/M390-T001-00A	TEMSITA5		

CPIN	CIRCUIT CARD ASSEMBLY	NSN	TECH ORDER
85E-USQ85/M390-T003-00A	TEMSITA4		
85E-USQ85/M390-T004-00A	TEMSITA6		

2.2 COMPILE TIME

All ATLAS test programs must be compiled using a 4 stage process. The first step is ATLAS. This step will check for syntax errors. Step 2, LNK, is optional. This step is used for ATLAS code housed in more than one file. The next step is FLOW. This step will determine the sequence of events in the program. The final step is the ALLOC, resource allocation step. This will create the object code require by the MATE test executive.

Compile time varies based on the complexity of the test sequence. The ATLAS phase takes several minutes for each module. The LNK step depends on the number of modules in the link. The most time consuming step is the FLOW. If a program has a simple test sequence the time will be short. On the other hand if the program was coded a vast amount of loops this step will be time consuming. The 91350 test program has a complex looping structure. It took 168 hours to compile on the VAX. The ALLOC step requires several minutes per TPS. The time is also dependant upon the sequence file output from the FLOW step.

The length of time required compiling makes TPS maintenance cost prohibitive. The slightest change would take several days or even weeks to correct.

2.3 EXECUTION TIME

Once compiled the ATLAS program is executed using the MATE test executive (MTE). The time required to execute a test program is relative to the amount of operator interactions. Typical UUT test execution time on the VAX was around an hour. The analog self test ran for approximately 75 minutes, digital self test ran for 45 minutes and the probe test was less than 15 minutes.

Test execution time is the key area where a reduction in test time will yield significant cost savings. If a TPS runs for an average of 60 minutes, that would allow the operator to run 7 or 8 UUT a day. It the test time is reduced by 15 to 20 minutes per run, the operator can run 2 or 3 extra UUT a day.

Can changing the VAX to a PC yield this kind of time reduction? Part of the time required in test execution for the TEMS UUT is the loading of digital data to the digital word generator. The PC can do this at a faster rate. Another area where the VAX is slow is the loading of test data into memory.

The 91350 require 5 minutes to load all of the digital stimulus and response files into memory. The PC can do this in milliseconds.

Statement execution on the PC is significantly faster. The VAX test programs use delay loops to wait for signal setup. These loops had to be modified to accommodate the speed difference. This difference is around 1.5 to 2 times faster on the PC.

2.4 BASELINE

Before work on the upgrade could commence, the baseline of the MATE 390 system needed to be determined. The actual TPS that were in operating was determined. Test execution times and compile times were observed. The source code for all TPS was collected. This last step was difficult. There were several pieces of data on missing. The instrument database and the switch data base source code were not on either VAX. The only copy of the code was a hardcopy listing. This had to be entered in by hand. The copy was too light to scan in and use an OCR.

There were two boards that were using HITS and the HITS diagnostics were to be reworked. It was discovered that Kelly AFB personnel were reworking these two TPS. The HITS simulator could not be ported over to the PC. These boards were the 90290 and the 92500. Both boards were to be reworked on another contract. It was also discovered that two TPS were either not available or were never developed. They were the 91150 and 90280. These two boards would have to be developed on a later contract. Several TPS would not execute completely through. Kelly AFB personnel were to correct these issues and send updates to the code when completed.

With the baseline completed and the required data collected, work began on re-engineering the MATE 390.

3.0 VAX TO PC UPGRADE

3.1 COMPUTER SPECIFICATION

The following computer was selected to replace the Micro VAX II:

- ❑ Dell PC using Pentium II Processor at 300 MHz
- ❑ 8 Gbyte fixed drive
- ❑ Sony DDS Tape Drive (DAT)

This computer was selected for speed and disk storage space. The system is required to house both the SCO-UNIX and Windows-NT operating systems. At the time of selection the Pentium II was the fastest processor on the market.

3.2 UPGRADE TASK DESCRIPTION

The integration of the PC with the MATE 390 test hardware has both a software and hardware component. Both are dynamically interrelated. The tasks will be broken down into hardware and software tasks. This does not imply that they were preformed in that sequence. The hardware and software tasks were preformed concurrently.

GPIB/IEEE-488 Bus Installation – The computer was set up to run both UNIX and Windows-NT. The GPIB card that works under UNIX does not work under Windows-NT. There is not one GPIB card that will operate under both operating systems. Therefore, two GPIB cards were installed in each computer. The GPIB/PCI-488 was installed for UNIX and the GPIB/TNT-488 was installed for Windows-NT.

Windows/UNIX Installation – The PC was set up with two operating systems. This is not a normal setup. Usually only one operating system is present on the PC. To accomplish this task the hard disk was partitioned as follows.

Table 2. Partition Table (in UNIX)

PARTITION	STATUS	TYPE	START	END	SIZE
2	Active	UNIX	32640	249389	216750
3	inactive	DOS (32)	255	32639	32385
4	inactive	UNIX	1	254	254

This will allow both operating systems to exist on the compute at one time. For the user to switch between systems they must reboot the computer.

3.3 UNIX/ATLAS TPS INTEGRATION

MATE Software Compile – For the MATE test software to operate on the new platform they must be recompiled. The MATE system was written using both C and Jovial languages. IE had the original source code in their software repository. The Jovial and C source code and build files were installed on the PC under the UNIX operating system. The files were installed in the /mcss directory. All support programs were compiled and the executable files were stored in /u/mate/programs. The following programs were compiled:

- ❑ atlas – Atlas Compiler
- ❑ lnk – Atlas linker
- ❑ flow – Atlas sequence flow generator
- ❑ alloc – Atlas resource allocation
- ❑ mte – MATE Test Executive
- ❑ bddb – Build Instrument Database
- ❑ bita – Build Interface Switch File
- ❑ bsdb – Build Switch Database
- ❑ ace – Atlas Code Extender

ATLAS Support Files – For the test programs to know where to find the resources and know how to switch the them out to the MAC panel interface. This is accomplished with the following programs:

- ❑ bddb – Build Instrument Database
- ❑ bita – Build Interface Switch File
- ❑ bsdb – Build Switch Database

The Instrumentation Database contains a listing of the MATE test equipment and their specifications. The file is compiled with the bddb file. This will create the data file containing all of the unique CIIL commands for the instrument. This file will be used during the alloc process. The source file for this step was not available. A hard copy was obtained and the source was coded. There were a few typos to correct and the mateidb file was created.

The Switch Database contains a listing of all of the MAC panel pins and what instrumentation they can be switched to. The bsdb file will translate this file for the Racal-Dana switching commands. The source file for this step was also unavailable. Fortunately a hard copy was obtained and the matesdb file was created.

The Interface Test Adapter file contains a mapping of UUT pins to MATE MAC Panel pins. The bita command will create the unique switching file required during the alloc process. Each test program has its own ita file. These must be translated before the ATLAS source code can be compiled. All of the test programs had an ita file.

ATLAS TPS Compile – Each TPS was recompiled on the PC. This is accomplished with the following programs:

- ☐ atlas – Atlas Compiler
- ☐ lnk – Atlas linker
- ☐ flow – Atlas sequence flow generator
- ☐ alloc – Atlas resource allocation

The following test programs were compiled on the PC. Included in the table are the compile times.

Table 3. TPS Compiling Times

TPS COMPILING TIMES	
Program	*Time (Min:Sec.Fraction)*
Mateidb	00:06.5
Matesdb	00:00.1
90280	00:22.5
90285	00:08.2
90290	00:05.9
91250	01:09.5
92450	02:15.2
92500	00:08.2
ITA4	00:11.7
ITA5	00:10.5
ITA6	00:12.7
90285	00:07.8
91150	02:41.3
91200	00:26.0
91300	00:13.7
91350	15:55.1
91450	00:30.1
91460	00:28.6
91600Ram1	00:29.6
91600Ram2	00:34.7
91600Ram3	00:37.3
91600Ram4	00:42.5
91650	03:14.2
91750	01:50.8
92500	00:08.4
Digital Self Test	00:22.5
PROBE Self Test	00:02.2
Analog Self Test	00:41.3

Instrumentation Timing – Once the Atlas TPS were compiled, they were executed on the test station. This was accomplished using mte. The programs did not execute correctly on the first attempt. The PC and the GPIB cards operate faster than the GPIB card and the VAX. This caused timing issues in the transfer of data between the GPIB instruments. The timing of the data transfers was monitored and adjusted through software. Under UNIX the IEE-488 bus driver was modified to increase the inter-character transmit delay. This was required primarily for the DPEM module.

Several timing issues arose in the TPS execution and were corrected in ATLAS. Statement execution was running faster on the PC. All of the programs have delay loops to wait for signals to set up. These delay loops were lengthened to accommodate the faster statement execution time. The PC was executing statements at a rate 1.5 to 2 times faster than the VAX. In the 91450 test program one delay loop ran through 40 iterations on the PC before a signal was present. The VAX only required 30 iterations for the same signal.

3.4 ACCEPTANCE TEST FOR UNIX/ATLAS TPS INTEGRATION

The executions of the ATLAS test programs under UNIX were witnessed by the government in February of 1999 at Kelly AFB in San Antonio, Texas. The acceptance test plan demonstrated the compilation of all code, the build of all support files, and the execution of all applicable test programs. When the stations were shipped to Warner-Robins AFB in Warner-Robins, GA the VAX station was not connected. The maintenance personnel began using the PC version of the VAX from the start. To date no software problems have been identified from the upgrade for this phase.

4.0 LABVIEW INTEGRATION

4.1 INSTRUMENT DRIVERS

For the LabVIEW version of the MATE to operate, all test instruments must have software drivers developed. The MATE instruments use a language called CIIL. The CIIL instructions for the various settings are described in the instrument manuals. The command sequences are also described in the "log" file generated when a test program is executed in ATLAS. Using these two sources the LabVIEW instrument drivers were developed. The following instruments are on the MATE:

- □ Tektronix 2430M Oscilloscope
- □ Racal-Dana 1275 Switching Matrix
- □ Wavetek 178 Synthesizer
- □ Kepco Power Supply Programmer
- □ Fluke 8520A DMM
- □ NH P2213 AC Power Supply
- □ Racal-Dana 1996-02M Timer/Counter
- □ IE 9200 DPEM

Two instruments posed particularly difficult problems. The Racal-Dana 1275 switch and the IE 9200 DPEM. The Racal-Dana switch mapping was defined in the switch database. This file had to be deciphered and a translation table incorporated into the driver. The DPEM illustrated several problems. First, the LabVIEW driver was sending commands and data too fast for the DPEM to read. The inter-character delay problem seen in the UNIX upgrade was present here. The command writes were delayed and the DPEM began to respond. The second problem was the format of the digital data being sent back and forth between the DPEM and the PC. The manual illustrates the data as ASCII. This was interpreted as follows: A hexadecimal AA would be sent to the DPEM as character "AA." This was in error. A hexadecimal AA should be converted to the unsigned character equivalent. For AA this is the ASCII equivalent to 170. Another issue arose with the checksum for the data. A 16-bit check sum is sent with all digital data streams. This is 2 ASCII bytes. If the checksum is greater than 65535 then the checksum will equal the calculated checksum less 65536. In essence this will truncate the most significant bits above 2 bytes.

All instrument drivers were completed and verified in the Analog, Digital and Probe selftests and the 91350 test program.

4.2 SELF TEST PROGRAMS

The three self test programs were converted to LabVIEW. The programs were structured such that the test execution followed the same sequence. The tests can be executed individually or as a complete end-to-end program. The self test programs require more time to execute than the UNIX/ATLAS version of the same programs. LabVIEW has more software overhead and will run slower than the UNIX TPS.

4.3 UUT TEST PROGRAM

The 91350 RPM Fuel Flow test programs was converted to LabVIEW. The programs Go-Nogo tests were separated into individual VIs. The tests were integrated into TestStand as a test sequence. The execution of the TPS is slower than the UNIX/ATLAS TPS for the same reason listed above.

4.4 ACCEPTANCE TEST FOR LABVIEW INTEGRATION

The LabVIEW acceptance will be completed at Warner-Robins AFB after WRAFB personnel have had a chance to review what the project.

5.0 DOCUMENTATION

5.1 MATE OPERATOR'S MANUAL

The manual was developed in April of 1999 and will be delivered with of the test equipment manuals to WRAFB. This manual covers the complete operation of the MATE 390. From this manual the operator will learn how to power up and power down the system. They can also read how to switch between operating systems. The manual will also instruct the operator on test program execution and software location.

5.2 MATE TECHNICAL ORDER

The TO illustrates how the MATE 390 is structured. It defines all of the software and directory location. It also gives a detailed explanation of the self test programs. The manual was developed in December of 1999 and will be delivered with of the test equipment manuals to WRAFB. As part of the TO new instrumentation manuals were procured. Several manuals were out of print. These manuals were photocopied and will be shipped to WRAFB.

GLOSSARY

ALLOC - Allocate Command
This command allocates the resources required to execute the test program.

ATLAS - Abbreviated Test Language for All Systems
This is the test programming language for the MATE. It is also the command used on the VAX/PC to begin compiling TPS source code.

CIIL - Common Interface Intermediate Language
This is the command set that communicates to the test instruments.

COTS - Commercial Off-the-Shelf
A term used for products that are readily available in the commercial market.

FLOW - Flow Command
This is the command that is used after ATLAS or LNK to define the test CIIL sequence.

ITA - Interface test adapter
This is the device that connects the unit under test to the MATE 390 tester.

LNK/ - Link Command
This is the command used to tie modular test programs together after a successful ATLAS on each module.

MATE - Modular Automated Test Equipment

MTE - MATE Test Executive
The runtime environment for all ATLAS test programs on the MATE.

PC - Personnel Computer
This is a Pentium base computer. This will be the new controller for the MATE 390.

TEMS - Turbine Engine Monitoring System
This is the system for the UUT TPS on the MATE.

TPS - A Test Program Set
A collection of software routines that prove a device meets the functional specification.

UNIX
PC operating system to replace the VMS operating system from the VAX.

UUT - Unit Under Test
A term used for the circuit or device to be tested.

VAX
The Micro VAX II is a computer developed by Digital Equipment Corp. This is the original computer in the MATE 390.

MISSION
OF
AFRL/INFORMATION DIRECTORATE (IF)

The advancement and application of information systems science and technology for aerospace command and control and its transition to air, space, and ground systems to meet customer needs in the areas of Global Awareness, Dynamic Planning and Execution, and Global Information Exchange is the focus of this AFRL organization. The directorate's areas of investigation include a broad spectrum of information and fusion, communication, collaborative environment and modeling and simulation, defensive information warfare, and intelligent information systems technologies.